FOREST
RESEARCH REPORT

Nova Scotia Department of Natural Resources
Forest Research and Planning

Regeneration Survey of Five Year Old Clearcuts in Nova Scotia

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Contents

Introduction 1

Methods
- Site Selection Procedure 2
- Data Collection 2
- Survey Description 3

Results
- Stocking 4
- Height 7
- Density 8
- Future Cover type Potential 10

Summary 12

Literature Cited 12

Appendices 12

Introduction

Forest disturbances, such as clearcutting, fire, and wind, invariably trigger a natural regeneration response in forest sites. Natural regeneration develops from local genetic stock that originates from surviving "legacies" of the former forest (advance regeneration, seed banks, coppice, etc.), and from "seed rain" that enters the site from surrounding forests. The speed and direction of the regeneration process is dependent on ecological responses to elements such as soil, climate, seed source, microsite, and harvest method/disturbance type, as well as to chance events. An important consideration for sustaining forest yields is the establishment of desirable regeneration soon after harvest. Whether a site is artificially regenerated or not, natural regeneration plays an integral role both as competitor and contributor to the new forest, and must be a primary consideration in any management strategy.

The purpose of this study is to 1) determine the early development patterns of natural regeneration following clearcut harvesting in Nova Scotia; 2) provide data for updating regeneration stocking assumptions in the calculation of the Nova Scotia wood supply projections; 3) develop a "key" to predict type and timing of natural regeneration based on pre and post logging conditions; and 4) assist in management decisions through a better understanding of regeneration response to ecological conditions.

The intent of this initial report is to describe the survey methodology and present a summary of the stocking and density of natural regeneration found in this survey of unmanaged five year old clearcuts in Nova Scotia. Future reports are expected to examine the effect of other factors (i.e. microsite, climate, elevation) on regeneration.

This project was a joint partnership between the Canadian Forestry Service and the Nova Scotia Department of Natural Resources and was funded through the Cooperation Agreement for Forestry Development (CAFD) 1991-95 Federal Applied Research Program. Data collection and project management were carried out by Forest Resource Consultants Incorporated (FRC) of Truro, NS. Over a two-year period, Spring 1994 to Fall 1995, 374 sites representing clearcuts ranging in age from four to seven years old were surveyed.

Report FOR 2000-3

NOVA SCOTIA
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104-06463/

Methods

Site Selection Procedure

The original project objective was to survey 400 clearcuts, distributed to attain a balanced geographical representation, based on Louck s (1961) Site Districts. Using this target, the number of cutovers required for survey within each Site District was determined based on the percentage of area of the provincial land base that each Site District comprised. The initial search for potential clearcuts was carried out using visual assessments of 1: 250 000 colour prints produced from LANDSAT false colour infrared (bands 2, 3 and 4) satellite imagery at 1:1 000 000, as well as GIS based searches in the counties where data was available. These investigations identified a population of over 9, 000 forest clearings with the potential to meet the selection criteria. From this sample population, sites were randomly selected for survey within each Site District. Initial screening began with the delineation of selected clearings on the most recent 1:10 000 aerial photography. Many sites were eliminated through photo interpretation because they failed to meet the following survey criteria:

Clearcut Size:	2.0 ha or greater;
Standing Trees:	5 or less individual standing live trees/ha greater than 9 cm DBH;
Clumps:	4 or less tree clumps /ha;
Clearcut Width:	20 m or greater;
Post Harvest Treatments:	None (ie. no site preparation, planting, or other silviculture);
Clearcut Age:	4 to 7 years inclusive;
Other:	Intersection of cut by roads, rivers and special management zones was acceptable.

Further screening by field verification ensured that the final sites complied with all selection criteria and were eligible for survey. Throughout the screening process rejected sites were replaced with randomly selected alternatives within each Site District until the target number of clearcuts was obtained, or the population of sites was exhausted. If exhausted additional sites were selected from other Site Districts as replacements. Less than seven percent of the randomly selected clearings initially identified on the satellite imagery met final selection criteria. Of sites rejected, 27% were mistakenly identified as clearcuts; 27% had received silvicultural treatment; 20% did not conform to age prerequisites; and 13% were less than 2 hectares in size. In addition 10% contained too many residuals; and 3% were rejected for administrative reasons (eg. inaccessibility).

Data Collection

General

The Nova Scotia Resource Atlas (Anon., 1986) and the Nova Scotia Provincial Mapbook (Anon.,1992) were used to record elevation, Biophysical land region, precipitation, length of growing season, proximity to the coast, climatic region, heat units, and frost free days. Nova Scotia Soil Surveys (Agriculture Canada, 1958-1991) were used to determine soil series and texture.

Photo Interpretation of Preharvest Conditions

Photo interpretation of the most recent 1:10 000 aerial photos that showed the stand before harvesting was used to determine the preharvest conditions of stands prior to clearcut as well as all adjacent stands. Interpretation included stand boundaries, species composition in 10% classes, average stand height, crown closure, percent mortality and land capability. Stands were assigned a cover type as follows: softwood: 70% or greater softwood species in the overstory; hardwood: 70% or greater hardwood species, and mixedwood: all other stands.

Field Sampling Procedure

Clearcuts were systematically sampled at an intensity of 0.5% with a minimum of 16 plots and a maximum of 50 plots. One hundred and seventy-four clearcuts had sample areas exceeding 6.16 ha, therefore the 50 plot maximum resulted in a sample intensity on these cuts of less than 0.5%. Prior to field assessment, sketches were used to establish evenly spaced cruise lines, and plots. Circular 6.16 m^2 plots were established having a 1.4 m radius, representing a 2.48 m x 2.48 m (8 ft x 8 ft) spacing, or 1,624 trees/ha. At each plot, the microsite was described by recording: duff thickness, moisture class, factors limiting regeneration, aspect, relief, percent slope, and slope position. Both softwood and hardwood stocking were determined by recording the dominant (tallest and most vigorous) softwood and hardwood in each plot that, in the opinion of the surveyor, had potential to become a harvestable crop tree within 40 to 60 years. Therefore, each plot could contain both a dominant softwood and hardwood. If the plots were unstocked the necessity for fill planting was assessed.

Density counts were made for all trees "grouped "by, species, origin, and height within each plot. Crop tree potential, (an estimate of the potential of a dominant seedling in each "group "to have commercial value at maturity based on vigour, height growth and response to future treatment) and free to grow potential (a visual estimate of the seedlings ability to maintain dominance in the developing canopy through maturity without additional treatment) were determined for each "group ". When coppice growth was identified, the number of stems per stump was counted. Identification of lesser vegetation and shrubs was recorded by percent cover at each plot.

Survey Description

General

Over the two year sampling period, 374 five-year old clearcuts totaling 3 250 ha were surveyed using 14, 397 plots (Figure 1). This represents 4.3% of the 75 000 ha clearcut in Nova Scotia during the 1989 to 1990 period (Canadian Council of Forest Ministers, 1997). The average clearcut size surveyed was 8.7 ha with a minimum of 2 ha and a maximum of 72 ha. Despite initial sampling objectives, the distribution of surveyed clearcuts was somewhat unequal, with 54% occurring in the Eastern Region, (Pictou, Antigonish, Guysborough and Cape Breton Island), 28% in the Central Region, (Cumberland, Colchester, Halifax and Hants), and 19% in the Western Region, (Annapolis, Kings, Digby, Yarmouth, Shelburne, Queens and Lunenburg), (Figure 2. , Appendix I).

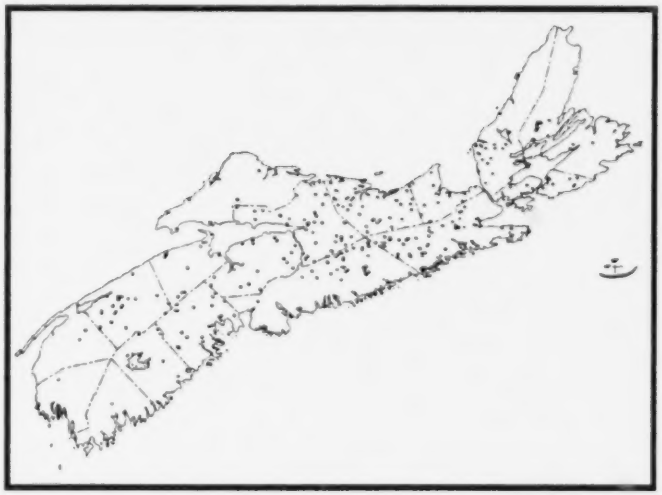

Figure 1. Distribution of 374 clearcuts (4-7 years old) sampled during 1994-1995.

Pre-harvest Conditions

Photo interpretation, before harvest, of each clearcut identified 868 stands or an average of 2.3 stands per clear cut area. This included 661 softwood, 111 mixed wood, and 96 hardwood stands. Seventy-one percent of the hardwood stands were dominated before harvest by intolerant species. Twenty-one percent of the cuts were comprised of single stands, 32% had two stands, 26% had three stands, and 21% had four to seven stands.

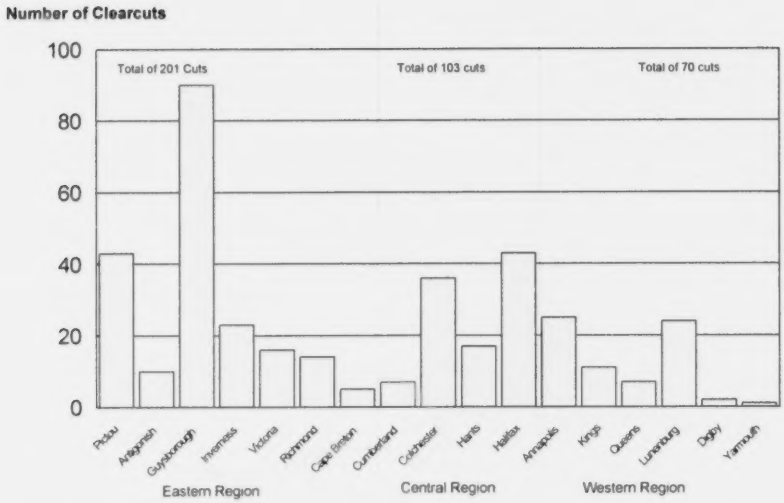

Figure 2 Distribution of 374 sampled clearcuts in Nova Scotia by county and region.

Photo interpretation indicated that the average species composition of the stands prior to harvest was as follows:

Softwood stands :	red/black spruce (52%); white spruce (15%); balsam fir (8%); larch, hemlock & Eastern white pine (6%); other softwood (8%) and hardwood (11%)
Mixedwood stands :	Intolerant hardwood (35%); red/black spruce(29%); balsam fir (8%) other softwood (15%); and other hardwood (14%).
Hardwood stands :	intolerant hardwood (48%); tolerant hardwood (24%); red/black spruce (10%); other softwood (11%) and other hardwood (6%).

Results

Stocking

Plot Level Stocking

Dominant Stocking

Over the 14 397 plots surveyed, stocking to commercial[1] species averaged 84 percent (Figure 3). Hardwood species were dominant in height in 48% of plots, while softwoods were dominant in 35 percent. In terms of height dominance, white birch had the most prevalent stocking, dominating 23% of plots. This was followed by balsam fir which was dominant on 16% of plots, and red maple which dominated 13 percent. Sixty percent of the commercially stocked plots contained both softwood and hardwood species.

Dominant Softwood Stocking

Independent of hardwood species, stocking of softwood regeneration averaged 68% for all stands, and 72% in stands that were classified as softwood prior to harvest (Table 1). This was made up of a 33 % stocking of dominant balsam fir, a 29 % stocking of dominant spruce species, and a 6 % stocking in

[1] Commercial and non commercial woody species with scientific names in Appendix V.

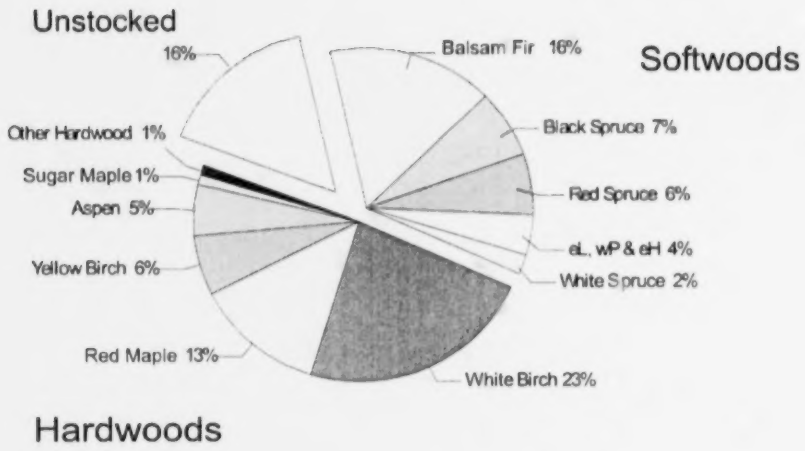

Figure 3. Stocking of tallest commercial species for all sample plots.

Table 1: Stocking (%) of dominant regeneration by preharvest covertype, where softwood and hardwood species are treated independently of each other (ie. a single plot could be stocked with both a dominant softwood and a dominant hardwood species).

Species	Preharvest Covertype (%)			
	Softwood (%)	Mixedwood (%)	Hardwood (%)	All (%)
Balsam Fir	33	40	33	33
Red Spruce	15	16	12	14
Black Spruce	13	4	4	11
White Spruce	5	3	3	4
Eastern Larch	4	1	1	3
Eastern White Pine	2	2	2	2
Eastern Hemlock	-	1	-	-
Total Softwood Stocking	72	67	55	68
White Birch	30	29	22	28
Red Maple	20	22	27	20
Yellow Birch	5	18	20	8
Trembling Aspen	4	5	5	4
Sugar Maple	-	2	7	1
Largetooth Aspen	1	2	2	1
Red Oak	-	1	2	-
White Ash	-	1	1	-
Total Hardwood Stocking	60	80	86	63
Total Stocking[1]	83	87	91	84
Number of plots	11 463	1 519	1 415	14 397

[1] Stocking to either a dominant softwood or a dominant hardwood.

which other conifer species were the dominant softwoods. Stocking to balsam fir was highest in the Eastern Region (40%) and lowest in the Western Region (22%) while red spruce rose from 5% in the East to 27% in the West (Appendix II).

Dominant Hardwood Stocking

Independant of the softwood species, stocking to hardwood regeneration averaged 63% for all stands, and 86% in stands that were classified as hardwood prior to harvest. This was made up of a 53 % stocking of dominant intolerant species (white birch, red maple, aspen), and a 10 % stocking in which tolerant species (yellow birch, sugar maple, red oak, white ash) were the dominant hardwoods. Dominant white birch stocking was constant across the Regions, averaging 28%, while red maple stocking ranged from a high of 27% in the Western Region to a low of 18% in Central Region (Appendix II). Although white birch had higher stocking overall, red maple had higher stocking on the hardwood covertypes.

Origin of Dominant Regeneration

The majority (88%) of dominant hardwood regeneration appeared to have originated from seed, while 12% was identified as having regenerated from either stump sprouts or root suckers. White birch and yellow birch regenerated primarily as single stems from seed (97%) and represented 57 percent of dominant hardwood stocking (Table 2). Coppice regeneration was most prevalent in largetooth aspen, averaging 48 percent. Sprout/sucker composition was also high in sugar maple, trembling aspen, and red maple, accounting for 47, 36, and 19 percent of the dominant stocking in these species respectively (Table 2). Black spruce was the only softwood to exhibit vegetative reproduction, with 22 % of dominant black spruce originating from layering.

Total Stocking

Plots were analysed to determine the total stocking of each species regardless of the height dominance within the individual plots. The result may be viewed as an indication of the maximum potential stocking that each species may attain. In general, the total stocking of most species was approximately 50 percent higher than the dominant stocking, indicating a significant potential for species composition to change through future stand succession and/or silvicultural intervention. Stocking for a number of species (eg. sM, bS) appeared to be influenced by preharvest covertype (Table 3). Alternatively, stocking to red spruce, balsam fir, and white birch appeared to be relatively independent of cover type.

Table 2 Origin of dominant hardwood regeneration.

Species	Seed Origin (%)	Sucker / Sprout Origin (%)	N[1]
White Birch	97	3	4 070
Red Maple	81	19	2 926
Yellow Birch	97	3	1 109
Trembling Aspen	64	36	597
Sugar Maple	53	47	163
Largetooth Aspen	52	48	109
Red Oak	82	18	49
White Ash	85	15	67
Dominant Hardwoods	88	12	9 090

[1] No. of plots where indicated species was recorded as dominant hardwood.

Table 3: Stocking[1] (%) of natural regeneration by preharvest covertype, where each species is treated independantly of the others (ie. A single plot could be stocked with a number of different species).

Species	Preharvest Covertype			
	Softwood (% Stocking)	Mixedwood (% Stocking)	Hardwood (% Stocking)	All Stands (% Stocking)
Balsam Fir	52	53	42	50
Red Spruce	20	23	17	20
Black Spruce	19	5	8	17
White Spruce	8	6	5	7
Eastern Larch	6	2	2	5
Eastern White Pine	3	3	3	3
Eastern Hemlock	1	2	1	1
White Birch	36	40	35	36
Red Maple	31	44	55	35
Yellow Birch	10	30	35	14
Trembling Aspen	6	8	10	6
Sugar Maple	1	3	13	2
Largetooth Aspen	1	3	4	1
Red Oak	0	1	2	1
White Ash	0	2	7	1
All Species	83	91	87	84

[1] Rated at the time of survey as "having crop tree potential"

Stand Level Stocking

An analyses of stocking levels within individual stands was made after conducting the following data manipulations: 1) Stands having the same covertype (preharvest, based on photo interpretation) and located within the same clearcut were combined, and considered as a single "merged" stand. This was done in order to maximize the number of plots in each "stand" available for analysis; 2) Following step 1, stands containing less than 10 sample plots were excluded from the analysis in order to ensure that stocking calculations were based on a reasonable number of plots per stand. These procedures reduced the original 868 "photo interpreted stands" to 448 *"merged stands"*, after excluding 13.8% of merged stands with less than 10 sample plots.

Results indicate that 90 % of stands were adequately stocked (> 60%) with commercial species (Appendix III). The percentage of adequately stocked stands was high regardless of covertype, with 89% of softwood, 95% of hardwood, and 93% of mixedwood stands having stocking of commercial species greater than 60 percent. When considered by regeneration type, 69 % of stands were >60% stocked with softwood regeneration, and 63% of stands were stocked to this level with hardwood species.

Height

Analyses of dominant commercial trees indicated that the average height of hardwood regeneration(136 cm) was nearly double the average height of the dominant softwood (77 cm) (Table 4). However, 42 percent of stocked plots contained softwoods whose height was equal to or greater than

that of hardwoods in the same plot, (including 21% of softwood stocked plots where hardwood regeneration was absent). Hardwood was equal or dominant to softwood on 62% of the stocked plots, (including 16% of hardwood stocked plots that did not contain softwood species).

Table 4 Height and dominance of tallest commercial softwood and hardwood in stocked plots.

Covertype	Mean height of Dominant SW (cm)	Mean height of Dominant HW (cm)	Height SW ≥ HW (% of stocked plots)	Height HW ≥ SW (% of stocked plots)
Softwood	76	129	46	57
Mixedwood	78	156	29	75
Hardwood	82	156	20	83
Mean	77	136	42	62

Largetooth aspen was the tallest species, averaging 226 cm in height (Figure 4). Eastern larch was the tallest softwood (144 cm) and sixth tallest of all commercial species. Six percent of the dominant stocked softwoods were 10 cm or less in height and 19 % were11- 30 cm or less, 25% were 30 cm or less (Appendix IV). For hardwoods two percent of the dominant trees were 10 cm or shorter and nine percent were11- 30 cm or less in height, 11% were 30 cm or less.

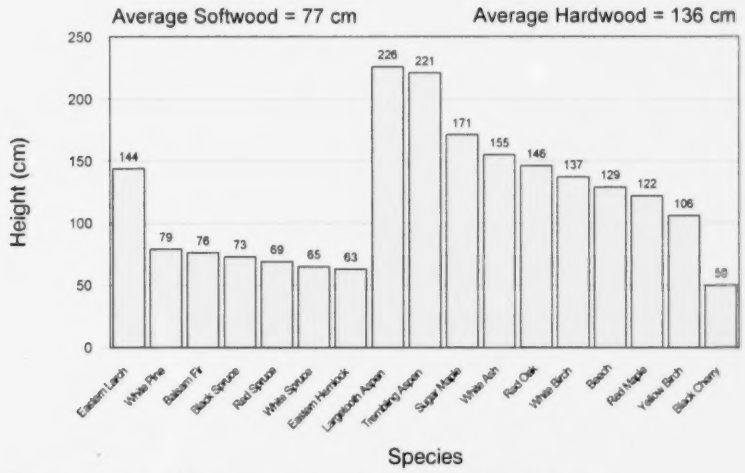

Figure 4 Average height of dominant commercial softwoods and hardwoods

Density

Stand density of all tree species (commercial and non-commercial) averaged 23,745 stems/ha, and ranged from 1,623 to 174,675 stems/ha (Figure 5). Only four percent of stands had less than 5,000 stems per hectare.

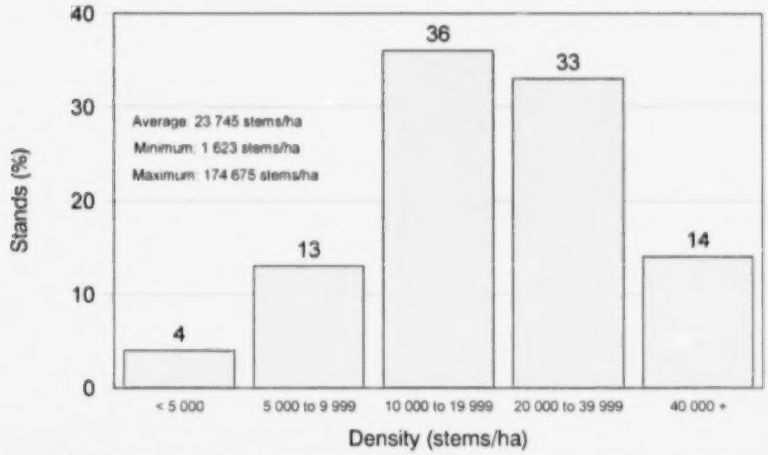

Figure 5 Percentage of stands by density of regeneration (commercial and non-commericial)

The density of commercial softwood species averaged 12 773 stems/ha, while commercial hardwood density averaged 8 349 stems/ha (Appendix V). Balsam fir was the most abundant species, comprising over one third of the total stem density (average 7 867 stems/ha) (Figure 6). White birch was second (3 666 stems/ha) followed by red maple (2 634 stems/ha), red spruce (2 257 stems/ha), and black spruce (1 652 stems/ha). Pin cherry was the leading non-commercial species (1 486 stems/ha), followed by grey birch (551 stems/ha). Average density of all commercial regeneration did not appear to vary greatly from one covertype to the next (Table 5.). However, the density of most individual species did appear to be influenced by covertype.

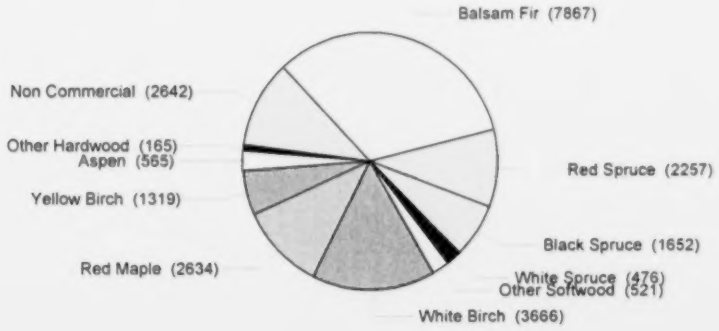

Figure 6. Average stem density (#/ha) by species for all stands.
Total Average Density = 23 745 stems/ha

Table 5. Average density of commercial regeneration by covertype.

Species	Softwood Stands (Stems/ha)	Mixedwood Stands (Stems/ha)	Hardwood Stands (Stems/ha)	All Stands (Stems/ha)
Balsam Fir	8 392	6 933	5 333	7 867
Red Spruce	2 325	2 514	1 494	2 257
Black Spruce	2 016	513	466	1 652
White Spruce	523	484	143	476
Eastern Larch	382	82	557	363
Eastern White Pine	117	109	72	111
Eastern Hemlock	42	67	48	46
Softwood Total	**13 797**	**10 702**	**8 113**	**12 773**
White Birch	3 611	3 925	3 747	3 666
Red Maple	2 199	3 144	5 035	2 634
Yellow Birch	822	2 473	3 395	1 319
Trembling Aspen	434	622	769	495
Sugar Maple	26	143	334	75
Largetooth Aspen	48	91	190	70
Red Oak	8	9	75	15
Beech	5	43	84	19
White Ash	19	103	222	52
Hardwood Total	**7 172**	**10 553**	**13 851**	**8 349**
All Commercial	**20 969**	**21 255**	**21 964**	**21 122**

Future Covertype Potential

Of the 448 merged stands with 10 or more plots, 409 were at least 60% stocked and therefore considered adequately regenerated (Refer to merging procedure under stand level stocking). These were further analysed to determine their potential to maintain their pre-harvest covertype classification based on a comparison of their current stocking levels with preharvest covertypes as determined by photo interpretation. The following criteria were used: to maintain a softwood covertype potential it was required that 75% of stocked plots contain softwood regeneration with crop potential and, likewise, to maintain a hardwood covertype potential it was required that 75% of stocked plots contain hardwood regeneration with crop potential. Mixedwood stands would be maintained if a minimum of 25% of stocked plots contained softwood regeneration and 25% contained hardwood. It should be noted that the indicated "potential" is dependant on future stand development and may often not be reached without intervention.

Overall 86% of adequately stocked stands had potential to maintain their original covertype. Eighty-three percent of the stands originally classified as softwood had the potential to maintain their softwood covertype, and 94% of hardwood stands had the potential to maintain their hardwood covertype (Table 6). Similarly, 98% of mixedwood stands had the potential to maintain their mixedwood covertype.

Table 6. Percentage of stands by with potential to maintain preharvest covertype. (Only stands with a minimum of 60% stocking of commercial softwood and hardwood regeneration and at least 10 stocked plots were included.)

Pre Harvest Covertype	Covertype Potential (Percent of Stands)			Stands N
	Softwood[1]	Mixedwood[3]	Hardwood[2]	
Softwood	**83**	97	53	304
Mixedwood	57	**98**	84	51
Hardwood	32	94	**94**	54
Total[4]	73	97	62	409

1 ≥75% of stocked plots contain crop potential softwood regeneration.
2 ≥75% of stocked plots contain crop potential hardwood regeneration.
3 ≥25% of stocked plots contain crop potential softwood regeneration, and ≥25% contain crop potential hardwood regeneration.
4 weighted by the number of stands included in each covertype.

Species Distributions (Occurrences)

Balsam fir had the greatest distribution regenerating in 807 of 868 stands, and red maple was second occurring in 749 stands (Figure 7). White birch was present in 723 stands, pin cherry in 595 stands, red spruce in 422 stands, black spruce in 421 stands and yellow birch in 402 stands.

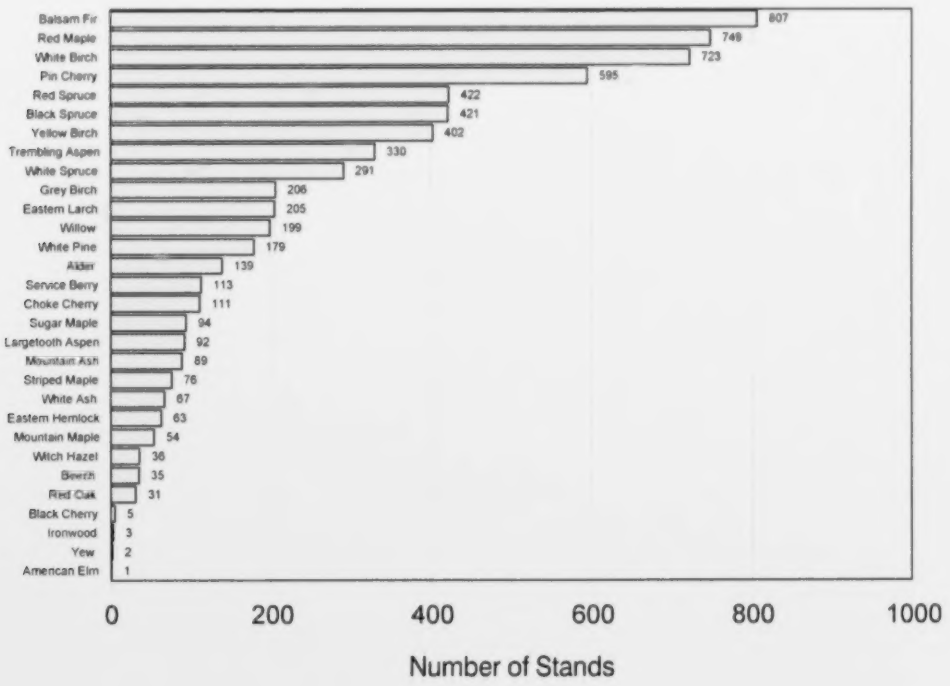

Figure 7. Frequency of occurrence of trees and shrubs

Summary

Between 1994 and 1995, 374 unmanaged clearcuts, 4 to 7 years old, comprising 3 250 ha and 868 stands were surveyed to study natural regeneration. The major results pertaining to stocking, density and height are as follows:

1. Overall, 84 percent of the surveyed area was stocked with commercial species, based on a target stocking of 1624 well spaced trees/ha (2.48 m x 2.48 m spacing).
2. Softwood stocking was 68 %, consisting of 33 % stocking of dominant balsam fir, 29 % dominant spruce species, and 6 % stocking in which other conifer species were the dominant softwoods.
3. Hardwood stocking was 63 %, which included 53 % stocking of dominant intolerant species (white birch, red maple, aspen), and a 10 % stocking in which tolerant species (yellow birch, sugar maple, red oak, white ash) were the dominant hardwoods.
4. Ninety percent of stands were at least 60% stocked with commercial species.
5. Sixty-nine percent of stands were stocked with 60% or more softwood regeneration and 63% percent of stands were stocked with 60% or more hardwood regeneration.
6. Stem densities of all tree species averaged 23 745 stems/ha, of which 21,122 were considered commercial species.
7. The average height of dominant hardwood regeneration (136 cm) was almost double the average height of dominant softwood regeneration (77 cm).
8. Eighty-six percent of adequately stocked stands had the potential to maintain their original, pre-harvest, covertype classification.
9. Balsam fir had the highest distribution occurring in 807 of 868 stands.

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Appendices

Appendix I - Site Selection and Survey Summary.
Appendix II - Stocking(%) of Dominant Regeneration by Region and Covertype (based on plot data).
Appendix III - Cumulative Stocking (% of Stands) 0f Regen Types by Province, Region and Covertype.
Appendix IV - Height distribution of Dominant Stocking for each Species.
Appendix V - Average stem density per hectare of all Stands, by height class and species.

Appendix I Site selection and survey summary .

Louck's Eco Regions	Louck's Site Districts	Percentage of Nova Scotia Land Area	Potential Cuts Identified in District	Sample Required for Survey	Actual [1] Number of Cuts Sampled	Percentage of Potential Cuts	Avg Sample Area (ha)
1 - Restigouche - Bras d' Or	1 - Guysborough - Bras d' Or	8.1	1588	30	36	9.6	7.4
2 - Magaguadavic - Hillsborough	2 - East River - Antigonish	4.0	1386	15	20	5.3	6.8
	3 - LaHave	3.8	162	14	10	2.7	7.6
3 - Maritime Uplands	4 - Cobequid Mountains	3.4	236	13	13	3.5	13.3
	5 - Musquodoboit Hills	5.1	599	19	35	9.3	9.2
	6 - Pictou Uplands	2.2	752	8	13	3.5	6.6
	7 - Cape Breton Hills	3.7	646	14	19	5.1	4.9
4 - Clyde River - Halifax	8 - Clyde River	4.9	21	18	1	0.3	4.0
	9 - Mersey River	4.1	147	15	10	2.7	5.6
	10 - Fisher Lake - Halifax	13.0	312	48	44	11.8	10.2
	11 - Wentworth Lake	2.4	55	9	1	0.3	3.3
	12 - Annapolis	2.8	50	10	1	0.3	3.1
5 - Maritime Lowlands	13 - Northumberland Shore	2.7	303	10	10	2.7	6.0
	14 - Oxford	4.2	390	16	8	2.1	5.0
	15 - Windsor - Truro	6.3	685	24	35	9.3	8.3
	16 - St. Mary's River	2.2	384	9	18	4.8	10.0
	17 - Sheet Harbour	5.1	370	19	31	8.3	9.6
6 - Fundy Bay	18 - Chignecto	1.8	89	7	6	1.6	7.8
	19 - North Mountain	2.1	71	8	8	2.1	5.1
7 - Atlantic Shore	20 - Cape Sable	5.0	107	19	2	0.5	3.9
	21 - Eastern Shore	10.0	1403	37	40	10.7	8.8
8 - Gaspe - Cape Breton	22 - Cape Breton Highland	3.1	72	12	13	3.5	20.8
8 EcoRegions	**22 Site Districts**	**100**	**9828**	**374**	**374**	**100**	**8.7**

[1] In cases where the cuts sampled is below the objective, all potential clearcuts were examined in that district. In such cases additional cuts were selected from other districts.

Appendix II Stocking (%) of Dominant Regeneration by region and covertype (based on plot data)

Species	Eastern Region				Central Region				Western Region			
	Precut Covertype				Precut Covertype				Precut Covertype			
	Sw	Hw	Mw	All	Sw	Hw	Mw	All	Sw	Hw	Mw	All
Balsam Fir	39	41	49	40	28	33	34	29	24	17	20	22
Red Spruce	4	6	9	5	26	19	19	25	28	18	33	27
Black Spruce	15	5	2	13	13	7	7	12	8	1	4	7
White Spruce	6	3	2	5	2	2	5	2	4	2	3	4
Eastern Larch	4	-	-	3	4	1	4	4	3	2	2	3
Eastern White Pine	1	-	-	1	1	1	-	1	6	7	9	6
Eastern Hemlock	-	-	1	-	-	-	1	-	-	1	-	-
All Softwood	69	55	63	67	74	63	70	73	73	48	71	69
White Birch	31	23	27	30	28	23	29	27	27	21	33	27
Red Maple	19	28	19	20	17	25	24	18	27	28	27	27
Yellow Birch	5	24	24	9	7	23	13	9	4	10	5	5
Trembling Aspen	4	7	5	4	5	5	7	5	3	2	4	3
Sugar Maple	-	4	2	1	1	6	1	1	-	12	-	2
Largetooth Aspen	-	-	-	-	-	1	1	-	2	5	6	3
Red Oak	-	-	-	-	-	-	-	-	1	6	3	2
White Ash	-	2	1	1	-	1	1	-	-	2	1	-
All Hardwood	59	88	78	65	58	84	76	60	64	86	79	69
All Species[1]	82	94	87	83	83	88	87	84	85	91	90	87
N[2]	6120	698	888	7706	3271	350	326	3947	2072	367	305	2744

[1] Stocking to either a dominant softwood or a dominant hardwood .
[2] Number of plots.

Appendix III Cumulative stocking (% of Stands) of regen types by province, region and covertype.

Provincial Summary

Stocking Level	Softwood Cover types			Hardwood Covertypes			Mixedwood Covertypes			All Covertypes		
	SWD	HWD	ALL	SWD	HWD	ALL	SWD	HWD	ALL	SWD	HWD	ALL
	(% of Stands)			(% of Stands)			(% of Stands)			(% of Stands)		
> 10	99	95	100	100	100	100	100	100	100	99	96	100
> 20	97	91	99	95	100	100	100	98	100	97	93	99
> 30	94	86	97	91	100	100	95	96	100	94	89	98
> 40	91	78	97	73	100	100	89	96	98	88	83	98
> 50	82	65	93	66	95	100	78	89	96	80	71	94
> 60	75	54	89	46	95	95	58	84	93	69	63	90
> 70	60	39	83	27	86	95	42	73	93	53	49	86
> 80	41	24	67	22	78	89	22	56	75	36	34	71
> 90	20	11	46	11	53	71	2	35	53	16	19	50

Eastern Region

Stocking Level	Softwood Cover types			Hardwood Covertypes			Mixedwood Covertypes			All Covertypes		
	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen
	(% of Stands)			(% of Stands)			(% of Stands)			(% of Stands)		
> 10	98	93	99	100	100	100	100	100	100	98	95	100
> 20	95	88	98	97	100	100	100	97	100	96	91	99
> 30	91	82	96	91	100	100	91	94	100	91	86	97
> 40	87	76	95	72	100	100	88	94	97	85	82	96
> 50	78	65	90	69	100	100	73	88	97	76	73	92
> 60	71	56	87	44	100	100	52	82	91	65	65	89
> 70	56	41	80	31	88	100	39	76	91	51	52	84
> 80	41	25	65	25	78	94	9	61	70	35	37	70
> 90	22	11	46	16	59	78	3	30	49	19	20	51

Central Region

Stocking Level	Softwood Cover types			Hardwood Covertypes			Mixedwood Covertypes			All Covertypes		
	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen
	(% of Stands)			(% of Stands)			(% of Stands)			(% of Stands)		
> 10	100	95	100	100	100	100	100	100	100	100	96	100
> 20	100	90	100	92	100	100	100	100	100	99	92	100
> 30	98	87	99	92	100	100	100	100	100	98	90	99
> 40	94	76	99	85	100	100	92	100	100	92	81	99
> 50	86	59	96	62	77	100	92	92	100	84	64	97
> 60	79	49	89	46	77	77	67	83	100	74	56	89
> 70	65	35	85	23	77	77	42	75	100	58	44	86
> 80	39	21	67	23	69	69	42	42	83	38	29	69
> 90	18	10	45	8	46	54	0	33	42	15	16	45

Western Region

Stocking Level	Softwood Cover types			Hardwood Covertypes			Mixedwood Covertypes			All Covertypes		
	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen	SWD Regen	HWD Regen	ALL Regen
	(% of Stands)			(% of Stands)			(% of Stands)			(% of Stands)		
> 10	100	100	100	100	100	100	100	100	100	100	100	100
> 20	100	97	100	90	100	100	100	100	100	99	98	100
> 30	98	94	100	90	100	100	100	100	100	98	95	100
> 40	95	84	100	60	100	100	90	100	100	90	88	100
> 50	87	71	97	60	100	100	80	90	90	83	77	96
> 60	79	59	97	50	100	100	70	90	90	75	68	96
> 70	60	41	87	20	90	100	50	60	90	54	49	89
> 80	43	24	73	10	90	100	40	60	80	39	36	77
> 90	14	13	49	0	40	70	0	50	80	11	21	55

Appendix IV. Height distribution of dominant stocking for each species.						
Species	Percentage of Each Species Total Dominant Stocking					Number of [1] Dominant Stocked Plots (#)
	Height Class (cm)					
	1 to 10 (%)	11 to 30 (%)	31 to 100 (%)	100 to 200 (%)	200+ (%)	
Balsam Fir	6	21	49	21	3	4762
Red Spruce	7	19	56	18	1	2075
Black Spruce	4	17	58	19	2	1581
White Spruce	7	24	52	16	2	599
Eastern Larch	1	3	29	49	18	480
Eastern White Pine	9	18	48	22	3	246
Eastern Hemlock	8	31	42	19	0	36
Total Softwood [2]	**6**	**19**	**51**	**21**	**3**	**9779**
White Birch	2	6	31	46	16	4076
Red Maple	4	15	41	23	17	2899
Yellow Birch	2	9	44	39	6	1119
Trembling Aspen	0	2	17	36	44	569
Sugar Maple	3	4	21	45	28	162
Largetooth Aspen	0	4	17	27	52	106
White Ash	0	12	20	48	20	65
Red Oak	2	12	27	29	31	49
Beech	0	0	43	57	0	7
Black Cherry	0	0	100	0	0	1
Total Hardwood [2]	**2**	**9**	**34**	**37**	**18**	**9053**

[1] Based on a total of 14 397 plots.
[2] Weighted by the number of dominant stocked plots.

Appendix V Average stem density per hectare of all stands, by height class and species						
Species	**Height Range (cm)**				**All**	**Stands**
	1 to 10 (stems/ha)	**11 to 30 (stems/ha)**	**31 to 100 (stems/ha)**	**100+ (stems/ha)**	**Heights (stems/ ha)**	**N**
Balsam Fir (*Abies balsamea* [L.] Mill.)	879	2781	3666	541	7867	807
Red Spruce (*Picea rubens* Sarg.)	280	624	1222	130	2257	422
Black Spruce (*Picea mariana* [Mill.] B.S.P.)	187	567	786	112	1652	421
White Spruce (*Picea glauca* [Moench] Voss)	70	151	232	23	476	291
Eastern Larch (*Larix laricina* [Du Roi] K.Koch)	10	47	176	130	363	205
Eastern White Pine (*Pinus strobus* L.)	15	31	48	16	111	179
Eastern Hemlock (*Tsuga canadensis* (L.) Carr.)	9	16	17	3	46	63
Total Softwood	**1451**	**4218**	**6147**	**957**	**12773**	**868**
White Birch (*Betula papyrifera* Marsh.)	169	431	1576	1490	3666	723
Red Maple (*Acer rubrum* L.)	230	700	1219	485	2634	749
Yellow Birch (*Betula alleghaniensis* Britton)	51	163	702	402	1319	402
Trembling Aspen (*Populus tremuloides* Michx.)	4	10	84	398	495	330
Sugar Maple (*Acer saccharum* Marsh.)	8	14	30	24	75	94
Largetooth Aspen (*Populus grandidentata* Michx.)	0	2	13	55	70	92
White Ash (*Fraxinus americana* L.)	1	10	21	20	52	67
Beech (*Fagus grandifolia* Ehrh.)	0	1	8	9	19	35
Red Oak (*Quercus rubra* L.)	1	2	7	6	15	31
American Elm (*Ulmus americana* L.)	0	0	1	1	2	1
Black Cherry (*Prunus serotina* Ehrh.)	0	0	0	0	1	5
Ironwood (*Ostrya virginiana* (Mill. K.Koch)	0	0	0	1	1	3
Total Hardwood	**464**	**1333**	**3661**	**2891**	**8349**	**868**
Pin Cherry (*Prunus pensylvanica* L.f.)	7	67	422	989	1486	595
Grey Birch (*Betula populifolia* Marsh.)	29	50	161	311	551	206
Alder ((*Alnus rugosa* (Du Roi) Spreng.)	0	4	31	132	166	139
Willow (*Salix* spp.)	0	7	55	28	91	199
Choke Cherry (*Prunus virginiana* L.)	3	19	39	9	70	111
Mountain Ash (*Sorbus americana* Marsh)	2	13	29	16	61	89
Witch Hazel (*Hamamelis virginiana* L.)	1	2	26	31	59	36
Mountain Maple (*Acer spicatum* Lam.)	0	5	18	28	52	54
Service Berry (*Amelanchier* spp.)	1	9	29	6	45	113
Striped Maple (*Acer pensylvanicum* L.)	1	4	15	22	42	76
Ground Hemlock (*Tsuga canadensis* (L.) Carr.)	0	0	0	0	0	2
Total Non Commercial	**44**	**180**	**825**	**1572**	**2623**	**868**
All Species Total	**1959**	**5731**	**10633**	**5420**	**23745**	**868**